

Assignment №1

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1.1

One of the most central idea in systems thinking is making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure. Systems thinking is more an orientation or a perspective than it is a formula or prescription. It can be used to help people understand how systems work and how people can deal with them more effectively. It is a way of exploring real life rather than representing it. It is a technique to figure out what's going on. A corollary to this approach is the idea that structures matter much more than individual events in terms of determining outcomes.

The challenge in systems thinking is to try and make possible desired outcomes more probable.

1.2

Problem definition: The inventory was decreasing during the last year and finally at the end of the last year the inventory of finished goods is nearly empty. This problem is important, because over the year sales will decline.

Hypothesis: Inventory of finished goods – stock; production of goods – inflow; sales of goods – outflow. $\text{Outflow} > \text{inflow}$ over the entire last year.

Analysis: My hypothesis consistent with laws of marketing and does it explain the observed low sales.

Policy: Use the model to see effects of increasing production.

Implementation: In order to implement the policy we have to provide enough amount of labor, capital, and if that is possible than we need to increase capacity of production.

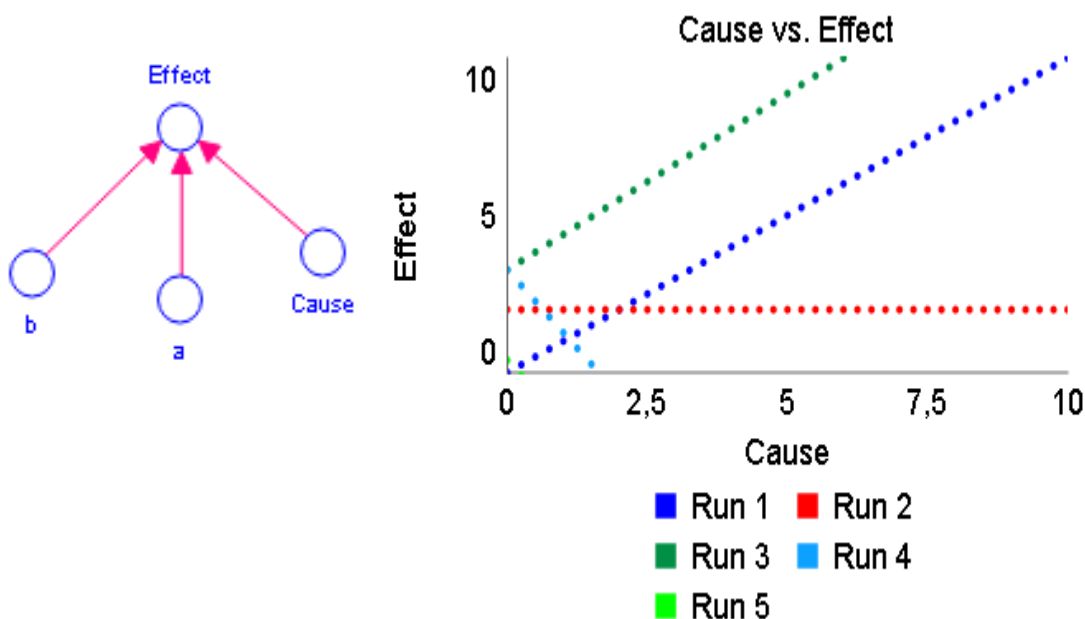
2.1

The observed problem behaviors serve as what we call a reference mode. The reference mode is what we want to explain with the model, what we build. It helps us focus by setting a boundary for what should be included in your model and the reference mode suggests what the time horizon for the simulation model should be (from start to stop time);

So, two reasons, which help us to identify or define a reference mode is it:

- settings boundary
- the time horizon

3.1 There are two types of instantaneous cause and effect relationships. This is linear relationships.



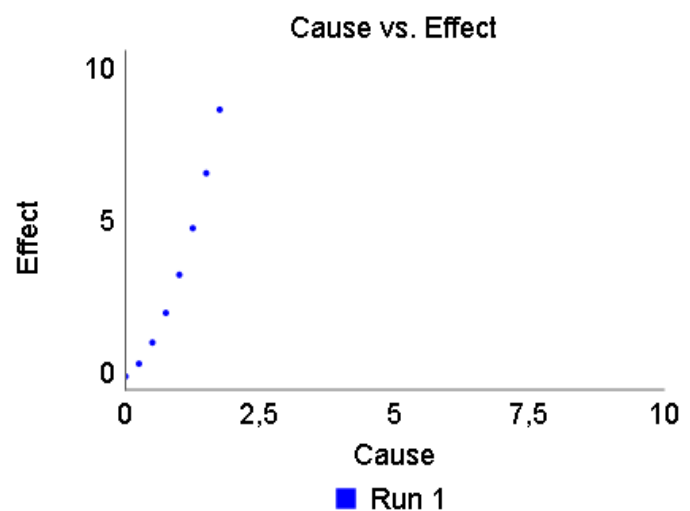
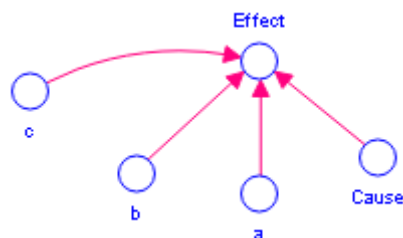
The mathematical definition of a linear relationship is the following: $Effect = b + a \cdot Cause$, where a and b are constants.

The linear cause and effect relationship can be portrayed as a straight line in diagram with the cause on the horizontal axis and the effect on the vertical axis.

When $b=0$, and $a=0$, we see that the effect is equal to the cause. The effect increases directly with the cause. If $a>1$, then a given increase in the cause leads to an even larger increase in the effect. If $b>0$, while $a=0$, then the effect depends only on the value of b . The effect does not vary with the cause.

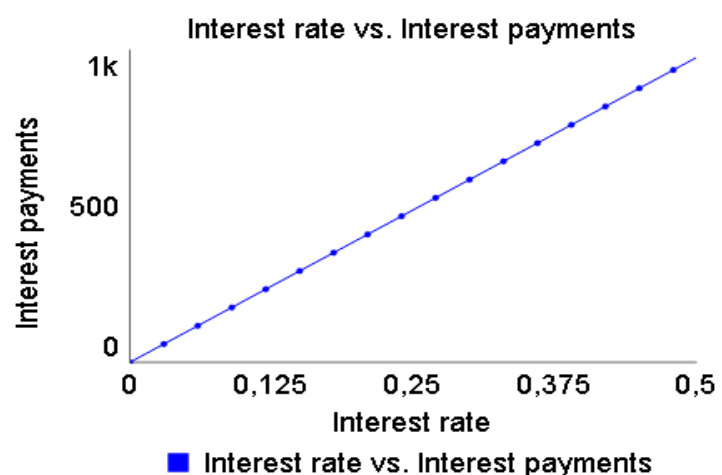
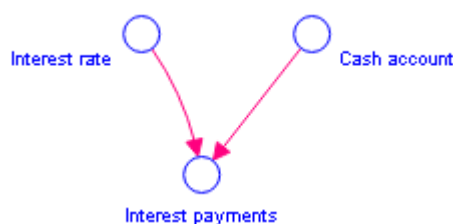
The general mathematical notation for a nonlinear relationship is $Effect = f(Cause)$ (the effect is function of the cause).

For instance, $Effect = b + a \cdot Cause + c \cdot Cause^2$, that it is all relationships that can not be portrayed by a straight line. In this case we have parabola.



3.2

- **Effect of interest rate on interest payments** - instantaneous relationship;



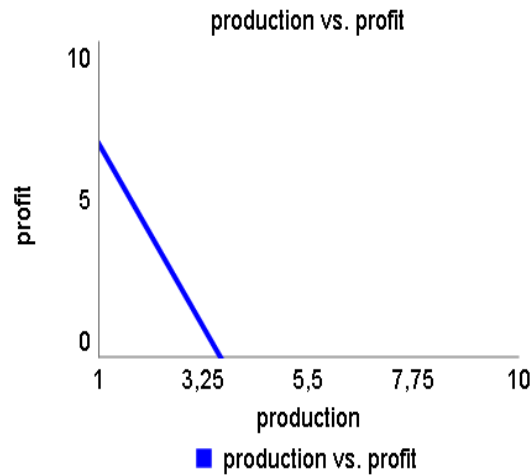
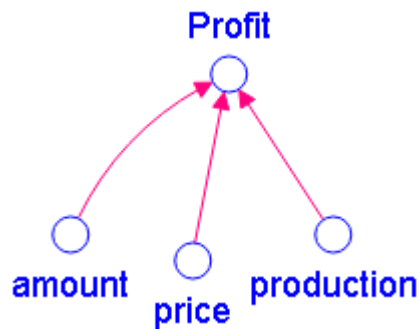
Interest rate - % per month

Interest payments – dollar per month

Cash account - dollar

Cash account = Interest rate*Interest payments

- **Effect of production costs on profits** - instantaneous relationship ;



Price – dollar

product price- dollar

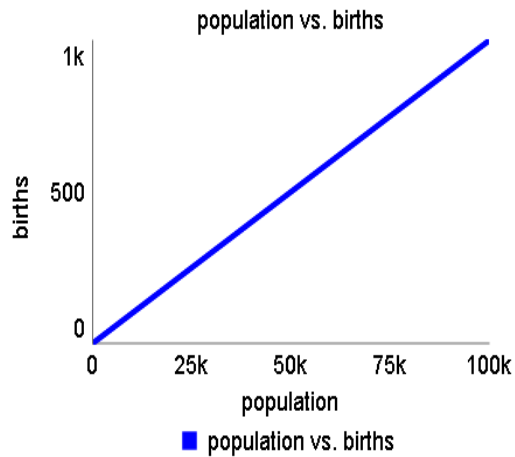
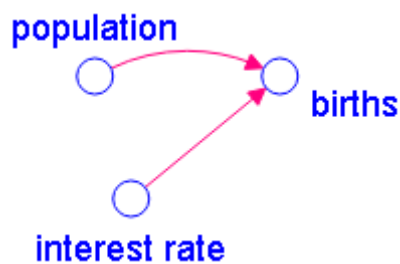
Profit=amount*(price-product price)

-**Effect of production on size of inventory** – accumulation relationship;

-**Effect of amount of water in a funnel on the outflow from the funnel** –accumulation relationship;

-**Effect of births on population size** - accumulation relationship;

-**Effect of population size on births** - instantaneous relationship



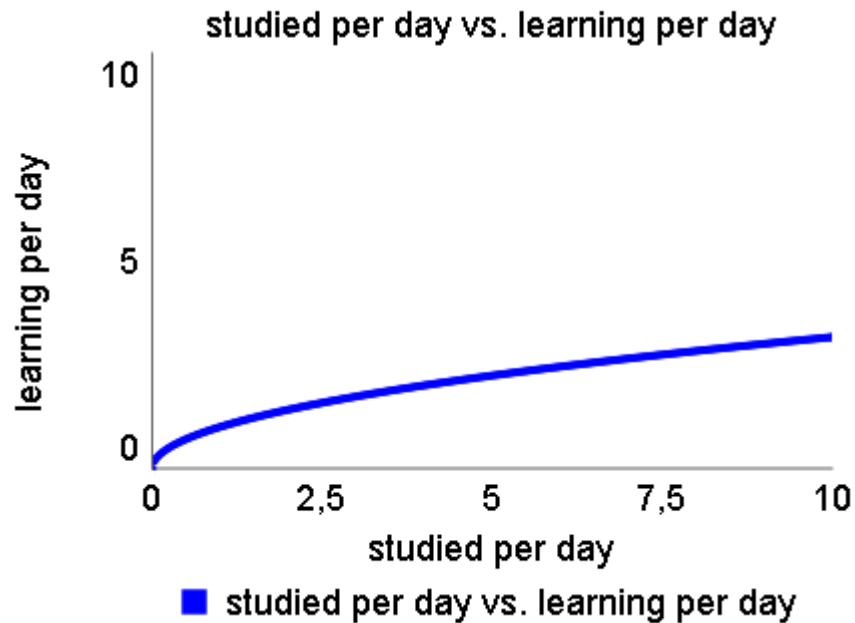
births=population*interest rate

birth rate: % per year, it is the same unitless per year

population – people

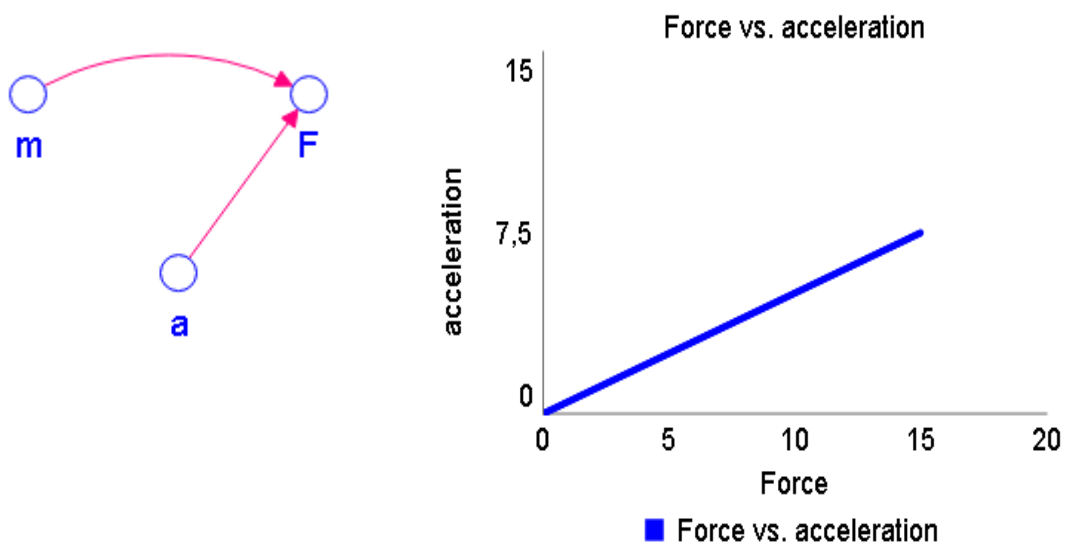
births-people per year

- Effect of hours studied per day on learning per day



- Effect of velocity on distance travelled - accumulation relationship;

- Effect of force on acceleration - instantaneous relationship



$$F=ma, a = F/m$$

Force: 1 H = kilogram*meter/second²

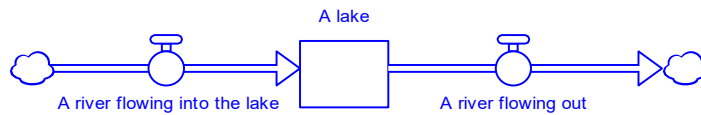
Mass: kilogram

Acceleration: meter/second²

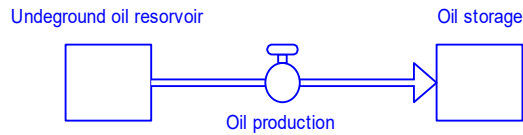
- Effect of acceleration on velocity accumulation relationship;

4.1

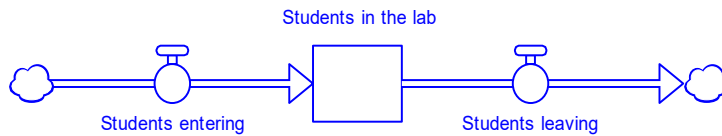
a) a lake, a river flowing into the lake and a river flowing out



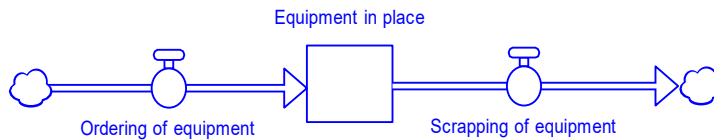
b) oil production, underground oil reservoir, oil storage



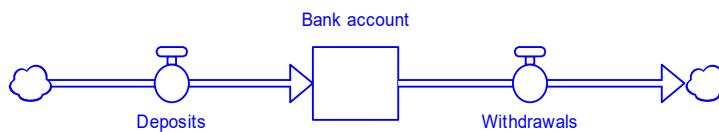
c) students in the lab, students entering, students leaving



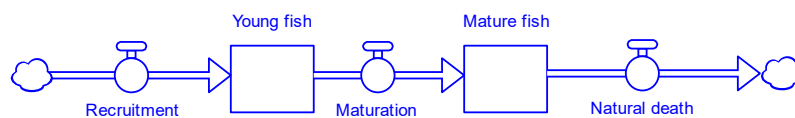
d) ordering of equipment, scrapping of equipment, equipment in place



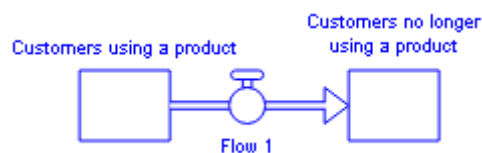
e) withdrawals, bank account, deposits



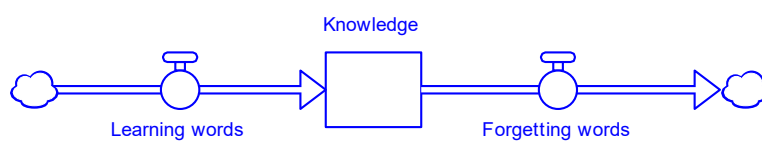
f) mature fish, maturation, natural death, recruitment, young fish



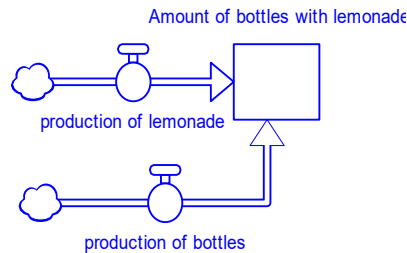
g) customers using a product and customers no longer using a product



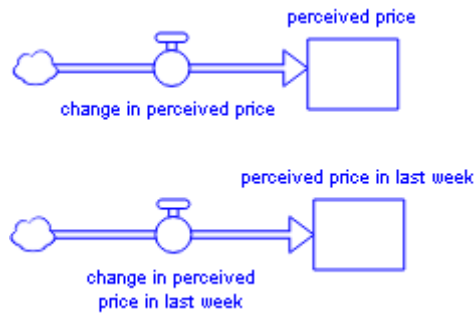
h) knowledge of words, learning words, forgetting words



i) production of bottles, production of lemonade, amount of bottles with lemonade



j) perceived price, perceived price last week, change in perceived price



Units for all the variables in question 4.1:

- a) liter per minute, liter, cubic meters, gallon, cubic meters per day,
- b) liter, barrel, liter for month or barrel for month
- c) people, people for hour
- d) unit per day, unit
- e) dollar per year, dollar, dollar per year
- f) kilogram per hour, kilogram
- g) people, people per day
- h) words per hour, words or just unit
- i) bottles per day, bottles or just unit
- j) dollar, dollar per week

4.2(b) According to the Euler method for integration (simulation) we have equation:

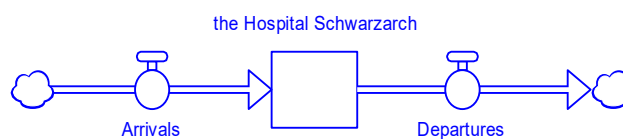
$$Stock_{t+1} = Stock_t + DT \cdot Flow_t$$

$Flow_t = (Inflow - Outflow) \cdot DT$. So as we can see, in order to find netflow we have to subtract in the same units.

Stocks add up flow over time. Flow must have the same per time unit for $Time\ step \cdot Flow$ to have the same unit as the stock. For example: Time step in minutes, all flows per minute.

a) When we simulate the model for us does not matter in which units Flow measures because for us does not matter in which units we add Flow to the Stock, Stock will not change. For us is important that stock and flows measure the same thing. Flow should determines what time unit to use in a model.

4.3



- a) The most patients arrived in 07.01.2001
- b) The fewest patients arrived in 03.01.2001
- c) The most patients departed in 13.01.2001
- d) The fewest patients departed in 31.12.2000-01.01.2001 and 06.01.2001

e) The most patients in the hospital were in 08.01.2001 because from 31.12.2000 to 08.01.2001 inflow exceeded outflow. Accumulates the inflow of patients leads of increasing in stock. That's why maximum of patients were at the end of growth.

f) The fewest patients in the hospital considering the entire period from the morning of 31.12.2000 to the afternoon of 13.01.2001 were in 13.01.2001, at the end of the period.